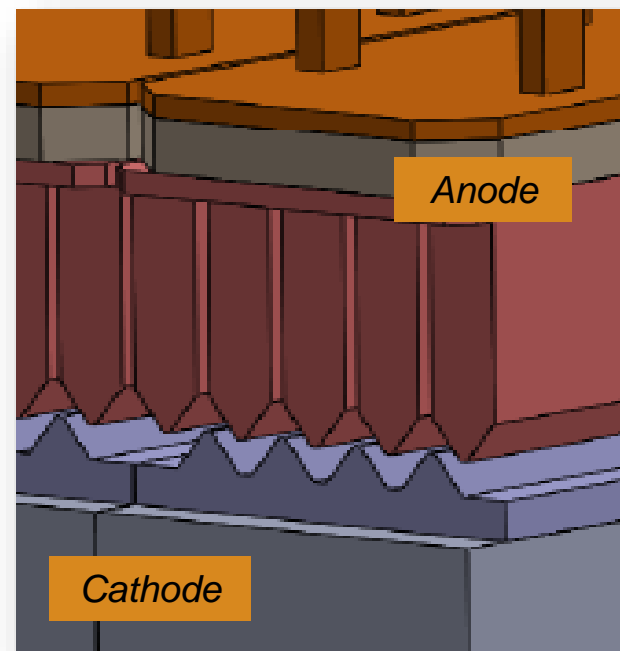


# Alcoa, Inc.

August 24 – 25, 2016

Detroit, MI

METALS Annual Meeting



## Technical Target set by ARPA e FOA:

- ✓ CO<sub>2</sub> emissions targets: 7 kgCO<sub>2</sub>/kg
- ✓ Cost targets for Al: \$1.50/kg
- ✓ Processing Energy: 11.2 kWh/kg

# Agenda

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- ▶ Team Intro
- ▶ Technical Concept
- ▶ Technical Progress to date
- ▶ TEA Highlights
- ▶ Demo Requirements
- ▶ Future Goals/Closing Thoughts
- ▶ Q&A

# Advanced Aluminum Electrolytic Cell



## **Organization:**

Founded in 1888, Alcoa maintains its position on the leading edge of aluminum technology and sustainability.

## **Team Member Names/Titles/Roles**

Mr. Mark Ripepi, Sr Project Leader, PM  
Dr. David DeYoung, Advanced Smelting Director  
Dr. Donald Ziegler, Smelting Manager, PI  
Dr. Rajneesh Chaudhary, Technical Specialist, Modeling  
Dr. Xinghua Liu, Sr Technical Consultant, T2M  
Dr. Derrick Lucey, Cell Operations Manager, Test

## **Project Goals:**

1. Design, Fabricate, and Operate a self heated pilot cell to develop side wall design, ledge formation, feeding, and operational controls.
2. Understand the durability of cathode laminate in production cell in conventional smelting cell.

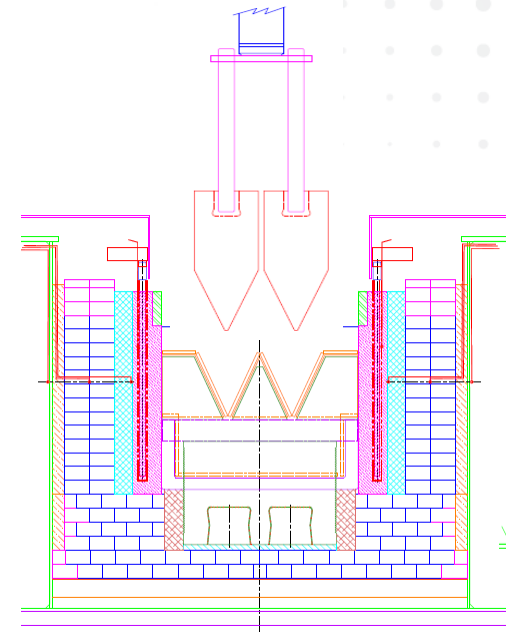
## **Project Summary:**

- ☐ Established wettable cathode surface
- ☐ Conducted Lab Scale to confirm basics operational criteria (900 amp)
- ☐ Confirmed economics for Greenfield plant is sound
- ☐ Stopped Heat Recovery effort due to economics of energy conversion and technical issue of current being carried by HX media.
- ☐ Scaled up test to single anode (6000 amp)
- ☐ Developed retrofit options to accelerate commercial demo
- ☐ Worked with ARPA on Plus-Up effort to exploit the retrofit option.

# Technical Concept



- ▶ What is the basis of your technical breakthrough?
  - Using a “wetted” surface concept for a cathode, the cathode surface can be “sloped” from horizontal
  - Enables a reduction in ACD, i.e. improve energy consumption
- ▶ What is novel about your approach?
  - Concept addresses wetted cathode block
  - Employs control logic from other advanced smelting efforts
- ▶ What are the benefits?
  - Reduction in the ACD improves performance and productivity
  - Uses conventional bath chemistry
  - Greenfield and retrofit potential
- ▶ How does it compare to existing solutions?
  - Utilizes lower cost materials
  - Retrofit has potential cost savings for existing assets
- ▶ Why was this project considered a good fit for ARPA-E Funding?
  - Lower energy consumption and emissions for a commodity driven industry which faces strong international headwinds

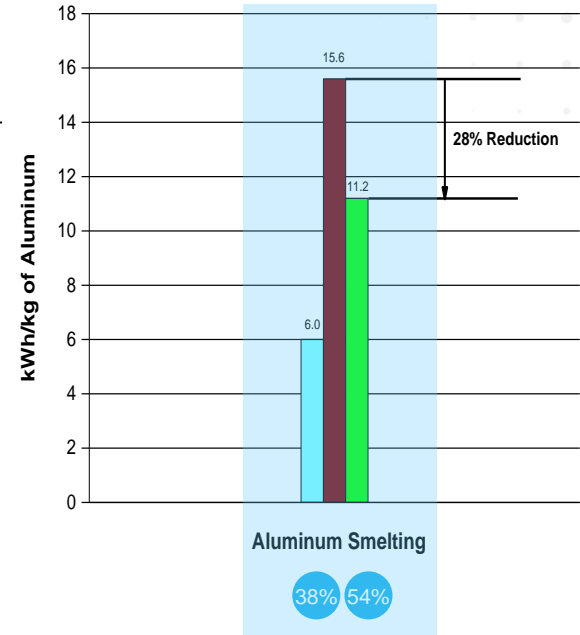
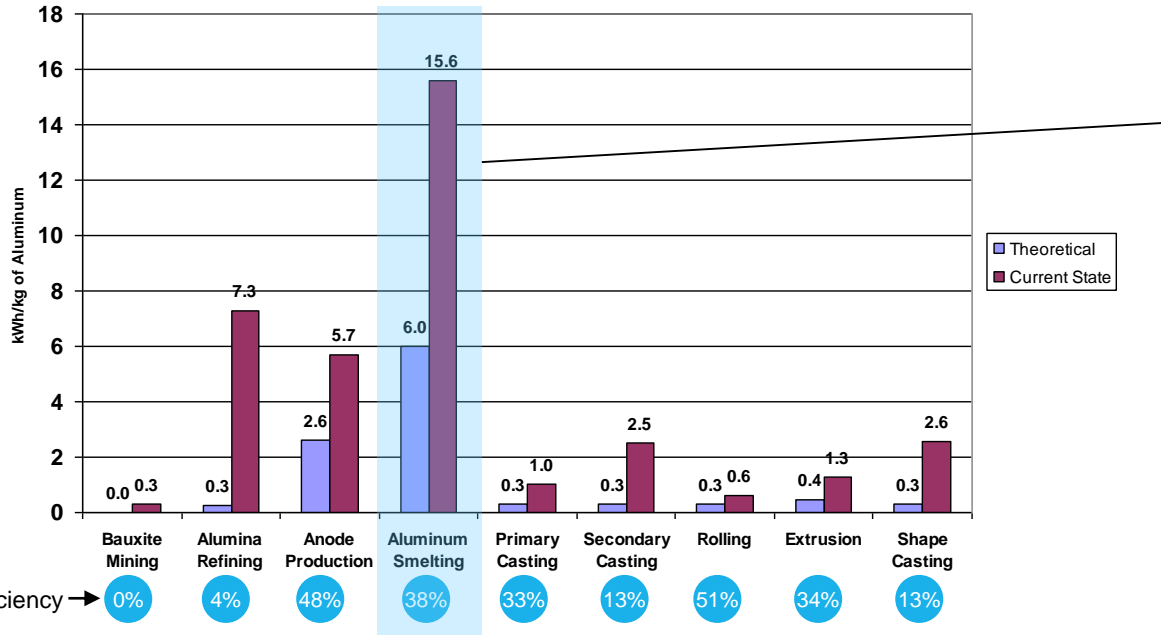


6000 Amp  
Bench Test

# Energy Efficiency in Aluminum Production



This Project Focus on Energy Efficiency Improvement for Aluminum Smelting



- Notes:**
- (1) "Current State" energy usage corresponds to the estimated energy used in a processing facility. These reflect reported industry averages reported in the reference.
  - (2) "Current State" energy usage does not include energy associated with the generation and transmission of electricity, the energy content of fuel products that are used as materials (e.g., carbon), or the energy required to produce fuels reported in the reference.
  - (3) "Efficiency" is the ratio of theoretical to current state energy usage

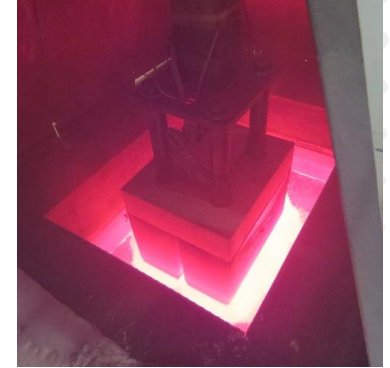
**Reference:** "US Energy Requirements for Aluminum Production: Historical Perspective, Theoretical Limits and New Opportunities," Choate and Green, January 2003

# Technical Progress to Date



## ▶ What are the overall project phases?

- Prove technical feasibility at lab and bench scale
- Show positive economic forecast
- Evaluate high temperature Heat Recovery to produce electricity
- Develop plan for pilot test (i.e. self heated cell)
- ❖ **Plus-Up:** Self-Heated test with a line of sight for plant demo



## ▶ Where do you stand vs. APRAE FOA project targets currently?

- ✓ Cost targets for Al: \$1.50/kg
- ✓ Processing Energy: 11.2 kWh/kg
- CO2 emissions targets: 7 kgCO<sub>2</sub>/kg
  - Impact related to Power Source(s), i.e. Hydro vs Fossil Fuel
- ✓ Testing: Anode effect minimal and perfluorocarbon PFC's not measurable

## ▶ What would you consider your biggest successes to date?

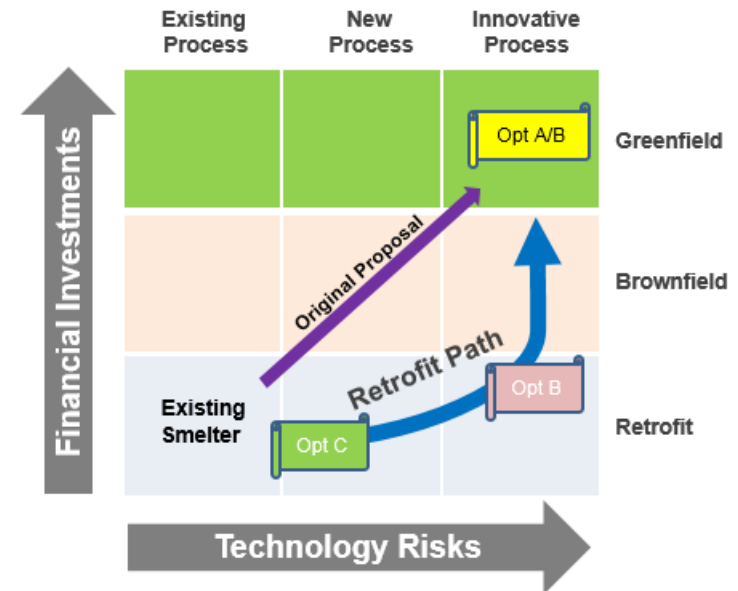
- Demonstration of 6000 amp cell with an ACD of 20mm
- Voltage targets were captured during testing

## ▶ Where do you still have additional work to complete?

- Proving durability of the cathode surface for extended period (6-7 yrs)
- Path to commercialization through retrofit will have technical issues (i.e. remodeling)
- Develop smelting cell which has heat balance to maintain small ACD and distribute heat for operational needs
- Limited resources and capital for R&D to develop Pilot Plant expenses

# TEA Highlights

- Develop innovative sloped cathode technology by exploitation of existing facilities to minimize the financial risk
- Deploy variations of the sloped cathode technology to create financial value for the US Aluminum Industry
- Targeting Cell Ranging: 240 - 650 kA



		Greenfield	Retrofit Options			
<u>Critical Variable</u>	Existing Smelter	Design A	Design B1	Design B2	Design B3	Design C
<b>Line Amp (Y-Multiple of Base Line )</b>	1.0Y	2.0Y	1.4Y	1.2Y	1.1Y	1.0Y
<b>Voltage Improvement</b>	n/a	28%	17%	9%	7%	2%
<b>Energy Consumption (KWh/kg)</b>	14.6	11.2	12.1	13.1	13.7	14.3
<b>Production Capacity Gain</b>	1.0X	2.0X	1.4X	1.2X	1.1X	1.0X

# Demo Requirements



## ▶ Demo Phase @ Operating Location:

- Single Pilot Cell 2xx kA, \$5-10M, 24 months
- Add 3 to 4 Pilot Cells after 1 year, additional \$xx M \*
  - Initial Pilot operation stable
- Autopsy initial cell at 24 months and continue to other Pilot Cells
  - Investigate the health of cathode surface
  - Cell ledge and side wall condition

## ▶ Projected Outcomes:

- Confirm cathode durability
- Confirm the Current Efficiency, Power consumption, Productivity

## ▶ Partnership needs:

- Internal: BU Commitment
- External: Government support



# Future Goals/Closing Thoughts



## ▶ **Ultimate End Goal for Project:**

- Implementation of technology
- Address showstoppers required for commercialization
- Solidify the economics and engineering required to deploy

## ▶ **Future Goals:**

- 5 years:
  - Fully operational supply chain
  - Commercial demonstration completed
  - Retrofit first plant underway
- 10 Year
  - Retrofit of 2<sup>nd</sup> plant complete
  - Deploy first Greenfield operation
    - (market dependent)

## ▶ **Prospective Impact on Industry**

- Technology to upgrade existing plants
- Reduced energy and carbon footprints for new and existing plants
- Technology addresses both Capex and Opex...



# QUESTIONS?